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(54) **Method for producing antiviral protein utilizing E.coli transformant, and gene and E.coli vector used in the method.**

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JOURNAL OF BIOLOGICAL CHEMISTRY, vol. 264, no. 12, 25 April 1989, Baltimore, US, pp. 6629-6637; HABUKA et al.: "Amino Acid Sequence of MIRABILIS Antiviral Protein, Total Synthesis of its Gene and Expression in ESCHERICHIA coli"

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D scription

This invention relates to a method for producing Mirabilis Antiviral Prot in.

Inventors of the present invention previously separated novel basic protein from Mirabilis jalapa and found that this protein showed antiviral activity (Published Unexamined Japanese Patent Application No. 243100/85). Specifically, this protein is Mirabilis Antiviral Protein (hereafter abbreviated as MAP). The inventors also cultured tissues of Mirabilis jalapa and succeeded in production of MAP utilizing the cultured tissue which obtained (Published Unexamined Japanese Patent Application Nos. 125382/87 and 269710/86).

MAP can be mass-produced industrially and easily by growing a large amount of Mirabilis jalapa and extracting MAP therefrom. However, this method has the disadvantage that both much time and an extensive planted area are required for growing Mirabilis jalapa. Methods utilizing cultured tissue disclosed in said Published Unexamined Japanese Patent Application Nos. 125382/87 and 269710/86 also require a long period of ca. 12 days for cell culture.

Meanwhile, with a rapid improvement of gene manipulation techniques, cloning techniques, etc. in recent years, productions of available substances using genetic engineering have been tried. Many trials have attained success. Additionally, in protein engineering, genetic approach is becoming important to study novel proteins. This is due to improvements of analyzing technique and DNA synthetic technique which are accomplished by accumulating fundamental studies.

Under the circumstances as said, some trials have been made in study of MAP to analyze the structure of MAP, to design MAP gene based on the analyzed MAP structures, and to synthesize it. The present inventors have also made the most of gene recombination and developed a method for producing MAP by introducing foreign genes into e.g. E.coli to produce MAP therein.

This method, however, suffers from the disadvantage that MAP produced and stored in E.coli inhibits biosynthesis of protein of E.coli itself. Therefore, growth of E.coli is inhibited and the amount of MAP produced therein does not readily increase, which limits the production of MAP.

On the other hand, in order to separate protein which accumulates in E.coli, a method is conventionally known to make a gene of signal peptide combine with gene for coding the objective protein and induce the produced protein to secret. Although many signal peptides are known, it requires practical experiments at present to know whether the desired effect can be obtained.

It is an object of the invention to provide a method for producing MAP which does not inhibit the growth of E.coli.

It is also an object of the invention to provide a gene which codes for MAP and is utilized as a foreign gene for said method for producing MAP.

It is a further object of the invention to provide recombinant plasmid which is integrated with said gene and is utilized as a vector in said method for producing MAP.

A method for producing MAP according to the present invention utilizes a gene as a foreign gene which is formed by making a gene for coding outer membrane protein OmpA signal peptide as shown in Fig. 1 combine with MAP gene having a nucleotide sequence as shown in Fig. 2 at its 5'-terminal. This method introduces the foreign gene into E.coli to transform it. This introduction uses a recombinant plasmid which is formed by integrating said foreign gene into a plasmid having E.coli expression system. The E.coli thus transformed produces MAP by expression of said gene, and also extracellularly transfer produced MAP. Therefore, no MAP accumulates in E.coli and growth of E.coli is not inhibited.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a signal sequence of OmpA and a nucleotide sequence for coding the signal sequence;

Fig. 2 shows a nucleotide sequence of a synthetic gene for coding MAP;

Fig. 3 shows a nucleotide sequence of a synthetic DNA linker; and

Figs. 4A to 4C show processes for forming a DNA vector including MAP gene and gene for coding the signal sequence according to an preferable embodiment of the present invention.

Preferable E.coli plasmid for utilizing as a vector in the invention maintains a number of copies in E.coli and includes a gene marker which make the bacteria to be resistant against antibiotics, etc.. Examples of the plasmids are pUC19, pBBR322, pKK223-3 and pTTQ19 plasmids, and other plasmid obtained by fusing some plasmids or by partially deleting bases from any one of the plasmids can also be used. An example of a fused plasmid is formed by fusing a region including replication origin (ori) and a part of ampicillin-resistance gene region (Ap) (i.e. a fragment obtained by digesting with restriction enzyme PvuI and PvuII) of pUC19, and a part of Ap, tac promoter region and $rrnBT_1T_2$ terminator region (i.e. a fragment obtained by complete digestion using PvuI and partial digestion using BamHI) of pKK223-3.

A vector for introducing a foreign gene which is to be expressed in E.coli generally requires the following DNA sequence other than the gene to be introduced;

(a) a region for operating transcription (operator)

(b) a region for promoting initiation of gene transcription (promoter);

Examples of promoters which are known to manifest in E.coli are N25 promoter and P_L promoter both of which are derived from coliphage, etc.. The P_L promoter is derived from E.coli lambda-phage and is known to be repressed by a control protein which is called cI. The cI includes temperature-sensitive mutant, called cI_{857}, which represses P_L promoter at 30 • C, like the cI, but loses its repressing ability at 42 • C, resulting in P_L promoter turn on. Accordingly, if an expression vector introduced in E.coli includes both P_L promoter and cI_{857} repressor gene, E.coli can be grown by culturing it at 30 • C such that P_L promoter is repressed. Also, P_L promoter can be turned on to initiate transcription of the gene by culturing E.coli at 42 • C.

The P_L promoter can be obtained by digesting lambda-phage gene or disclosed pPL-lambda plasmid with restriction enzyme BamHI and HpaI. The cI_{857} repressor gene can be obtained by digesting gene of lambda-phage mutant (cI_{857}, Sam 7) with restriction enzyme Bg1II and BanIII.

(c) a region for instructing termination of transcription (terminator)

Examples of known terminators are tLI terminator derived from coliphage, $rrnBT_1T_2$ terminator derived from ribosome gene of E.coli, etc..

(d) a region for instructing initiation position of transcription after transcripting into mRNA (Shine-Dalgarno, SD sequence)

A sequence which is common to construction gene of E.coli can be used as SD sequence.

(e) methionine codon which is linked to the SD sequence and is for initiation of translation (ATG)

A. Formation of E.coli expression vector

An expression vector derived from plasmid DNA can be formed by deletion or insertion of a specific region from and in the plasmid DNA. The deletion and insertion can be performed by cleaving the plasmid at specific sites and combining the resultant fragments by means of an appropriate treatment. Specifically, appropriate utilization of synthetic DNA fragments enables restriction enzyme sites, SD sequence, gene for coding amino acid sequence of protein, etc. which are not included in the original plasmid DNA to introduce.

For example, by making the DNA fragment and its complementary chain which are shown in Fig. 3 and include XbaI and BanIII sites that are not included in plasmid pKK223-3 to combine with a cleavage fragment (a large fragment) which is obtained by digesting the pKK223-3 with EcoRI-HindIII, the restriction sites of XbaI and BanIII can be introduced in the pKK223-3. Additionally, by utilizing this pKK223-3 which includes restriction sites of XbaI and BanIII and a fully synthetic MAP gene also having XbaI and BanIII sites in its 5'- and 3'-terminals respectively, the fully synthetic MAP gene can be introduced into the plasmid pKK223-3. Further, SD sequence and a codon for coding a methionine residue which is required for initiating transcription of gene can also be introduced into said plasmid at this time. Moreover, since restriction site of NdeI (CATATG) includes a methionine codon (ATG) in, a gene for coding other proteins can be introduced through this site.

Required DNA fragments can be synthesized by a DNA synthesizer. An expression vector is formed by combining DNA fragments obtained by the DNA synthesizer, those obtained by restriction enzyme cleavage, and such a DNA fragment as needed obtained by converting a cohesive end into a flush end utilizing T4 DNA polymerase, DNA polymerase Klenow fragment, etc.. Each fragment can be combined by T4 DNA ligase or a commercially available ligation kit including the DNA ligase.

B. Formation of Secretory MAP Gene

OmpA is an outer membrane protein of E.coli and comprises a signal sequence as shown in Fig. 1. A nucleotide sequence of a gene for coding this signal sequence is also shown in Fig. 1. This signal sequence functions to make OmpA to secrete from E.coli. Therefore, by linking this signal sequence to N-terminal of other protein, the protein can be transferred outside from inside of the E.coli. For example, by linking the signal sequence shown in Fig. 1 to N-terminal of MAP, MAP can be secreted from E.coli.

Further, a gene for coding the signal sequence has the first methionine codon included in a part of said NdeI sites, and thus a foreign gene can be introduced into an expression vector having the NdeI site which is downstream from a promotor.

Fig. 1 also shows a sequence of three amino acid of MAP N-terminal and a DNA sequence corresponding thereto. C. Production of MAP utilizing E.coli transformant.

According to the method as said, an expression vector can be prepared which is introduced with e.g. P_L promoter, cI_{857} gene, and a gene for coding a protein. This vector can be further utilized to transform E.coli by a disclosed method, e.g. by the calcium chloride method.

A medium for culturing the transformants may contain carbon source, nitrogen source, minerals and, on an as-needed basis, minor organic nutrition source such as amino acids, vitamins, etc..

The transformants can be cultured e.g. in a liquid medium under the aerobic condition by e.g. stirring with aeration, with 6.5 - 8.5 of pH maintained. The culture is performed for several hours to ca. four days to produce MAP and to allow it accumulated in a medium.

Next, the medium containing MAP obtained as said is condensed. The resultant solution is subjected to an appropriate combination of salting out, ion exchange chromatography, gel filtration, affinity chromatography, etc. to purify MAP.

One example is that a MAP gene or a gene obtained by combining MAP gene and a gene for coding signal sequence is inserted into an expression vector including P_L promoter and cI_{857} gene, and this vector is introduced into E.coli, allowing generation of MAP, firstly by culturing the transformed E.coli under the aerobic condition at 30°C to fully grow the bacteria, and immediately after that increasing a culture temperature to 42°C, followed by further culture under the aerobic condition. MAP can be thus efficiently produced.

MAP thus produced can be determined by an immunological technique utilizing anti-MAP antibodies.

Although the following is to describe the present invention in detail with reference to preferable embodiments, it is to be understood that the invention is not restricted to the description. To understand the following embodiments, processes of forming DNA vector in the embodiments are shown in Figs. 4A to 4C.

A Step of Inserting A Synthetic DNA Fragment into Plasmid pKK223-3

A DNA linker containing restriction enzyme sites, SD sequence, methionine codon, and coding N-terminal amino acid sequence of MAP shown in Fig. 3 was inserted into plasmid pKK223-3 (manufactured by Pharmacia Japan Co., Ltd).

One micro gram of pKK223-3 was incubated in High Buffer (a mixture of 50mM Tris•HCl [pH7.5]-100mM of NaCl-1mM of MgCl) containing 10 units of each restriction enzyme of EcoRI and HindIII (manufactured by Nippon Gene Co, Ltd.) at 37°C for one hour for digestion. The obtained solution was subjected to phenol-chloroform treatment and ethanol precipitation to collect DNA. The phenol-chloroform treatment is described in detail was follows. Firstly, phenol was saturated with a mixture (hereinafter abbreviated as TE) of 10mM of Tris HCl (pH8.0) and 1mM of ethylenediamine tetra acetic acid (EDTA). The equivalent volume of the resultant phenol solution was added to the obtained DNA solution for mixing, and the resultant mixture was centrifuged to collect a aqueous phase containing DNA. Next, an equivalent volume of chloroform was added to this aqueous phase for further mixing, and the resultant mixture was centrifuged to collect an aqueous phase containing DNA. Ethanol precipitation is described in detail as follows. Firstly, to the obtained solution containing DNA, 5M of sodium chloride of 1/20-fold volume and ethanol of 2-fold volume were added, and the resultant mixture was cooled at -70°C for thirty minutes. Next, this solution was centrifuged at high speed to separate the obtained precipitant.

Two kind of single-stranded synthetic DNA linkers of complementary nucleotide sequences shown in Fig. 3 were prepared by utilizing the DNA synthesizer (manufactured by Applied Biosystems Japan Company, 381A-type) according to the phosphoroamidide method. One microgram of each obtained synthetic linker was incubated in 100 μl of a kinase solution (a mixture of 50mM of Tris HCl [pH7.6], 10mM of $MgCl_2$, 5mM of dithiothreitol, 0.1mM of spermidine, 0.1mM of EDTA, and 1mM of ATP) containing 10 unites of T4 kinase (manufactured by Toyobo Co., Ltd.) at 37°C for one hour to add phosphoric acid to 5'-terminal of the linkers. After that, the obtained single-stranded DNA was converted into double-stranded DNA by annealing. This annealing was performed by mixing the obtained reacted solutions, heating the resultant mixture at 60°C for twenty minutes, and allowing it to stand at room temperature for twenty minutes. Next, the resultant solution was subjected to ethanol precipitation, and then the precipitate was dissolved in 10 μl of TE.

To 5 μl of the thus obtained solution containing double-stranded synthetic DNA, 2.5 μl of (ca. 0.5 μg) of pKK223-3 cleavage product was added and the mixture was ligated at 10°C for two hours utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd). Plasmid pKS2 was then obtained by introducing the synthetic DNA linker into the plasmid pKK223-3.

A St p of Converting Replication Origin of pKS2 to that of plasmid pUC19 Type

Two microgram of plasmid pKS2 and restriction enzyme BamH1 were incubat d at 37°C for one hour in 50 µl of High Buffer for digestion. Next, the obtained solution was subjected to phenol-chloroform treatment and ethanol precipitation to collect cleaved DNA. The obtained precipitate was added to 25 µl of Klenow solution (which is obtained by adding 0.1mM of each co-factor dATP, dGTP, dCTP and TTP to a mixture of 50mM of Tris•HCl [pH7.2], 10mM of MgSO4, 0.1mM of dithiothreitol, and bovine serum albumin of 50 µg/ml), and the resultant solution was incubated at 22°C for 30 minutes to convert a cohesive end of the DNA to a flush end. After reaction, the solution was heated at 70°C for five minutes, followed by phenol-chloroform treatment and ethanol precipitation to collect DNA. The collected DNA was further cleaved by dissolving it in 50 µl of High Buffer containing 10 units of restriction enzyme PvuI (manufactured by Toyobo Co., Ltd.) at 37°C for one hour. The cleaved DNA was collected by phenol-chloroform treatment followed by ethanol precipitation.

Separately, 1 µg of plasmid pUC 19 (manufactured by Takara Syuzo Co., Ltd.) was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme PvuI (manufactured by Toyobo Co., Ltd.) and PvuII (manufactured by Nippon Gene Co., Ltd.) at 37°C for two hours to cleave pUC19. The cleaved DNA fragments were collected by phenol-chloroform treatment, followed by ethanol precipitation.

The DNA fragments (larger fragments) derived from pKS2 and DNA fragments derived from pUC19 both of which were obtained as mentioned were dissolved in 10 µl of TE, respectively. After that, each 3.5 µl of the TE solutions were mixed and the fragments was ligated at 10°C for one hour utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd.) to obtain plasmid pKS3. This pKS3 comprises the replication origin of pUC19 and the large fragment of pKS2 which are combined therein.

A Step of Inserting P_L Promotor into pKS3

Two micrograms of pKS3 was incubated in 50 µl of High Buffer containing 10 units of a restriction enzyme PstI (manufactured by Nippon Gene Co., Ltd.) at 37°C for one hour for digestion. The cleaved DNA fragment was collected by phenol-chloroform treatment followed by ethanol precipitation. The collected DNA fragment was incubated in 20 µl of polymerase solution (which was obtained by adding 0.1mM of each co-factor of dATP, dGTP, dCTP and TTP to a mixture of 33mM of Tris•HCl [pH7.9], 66mM of potassium phosphate, 10mM of magnesium acetate, 0.5mM of dithiothreitol, and 0.1mg/ml of bovine serum albumin) containing 2.5 units of T4 DNA polymerase (manufactured by Toyobo Co., Ltd.) at 37°C for five minutes to convert a cohesive end of the DNA fragment to a flush end. Next, 1 µl of 0.5M EDTA was added to the resultant solution, and the obtained mixture was subjected to phenol-chloroform treatment and further ethanol precipitation to collect DNA. The collected DNA was incubated in 50 µl of High Buffer containing 10 units of restriction enzyme BamHI (manufactured by Nippon Gene Co., Ltd.) at 37°C for one hour for additional digestion.

Separately, 1 µg of pPL-lambda (manufactured by Pharmacia Co., Ltd.) was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme BamHI and HpaI (both manufactured by Nippon Gene Co., Ltd.) at 37°C for one hour for digestion. Next, the mixture was subjected to phenol-chloroform treatment and the following ethanol precipitation to collect DNA fragment containing the P_L promotor.

The DNA fragment derived from pKS3 and the DNA fragment containing the P_L promoter were dissolved in 10 µl of TE, respectively. Next, 3.5 µl of each solution obtained as said were mixed, and the DNA fragments therein were ligated utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd.). After that, the resultant DNA was utilized to transform E.coli (strain HB101). From the obtained transformants, plasmid pSH4 was prepared. This plasmid pSH4 is the plasmid which was formed by inserting the P_L promotor into pKS3.

A Step of Cleaving out cI_{857} Gene form Lambda-phage DNA

Two microgram of lambda-phage (lambda, cI_{857}, Sam7) DNA (manufactured by Takara Syuzo Co., Ltd.) was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme Bg1II (manufactured by Nippon Gene Co., Ltd.) and BanIII (manufactured by Toyobo Co., Ltd.) at 37°C for two hours for digestion. The obtained DNA fragments were collected by phenol-chloroform treatment followed by ethanol precipitation.

Meanwhile, 1 µg of plasmid pHSG397 (manufactured by Takara Syuzo Co., Ltd.) was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme BamHI (Nippon Gene Co., Ltd.) and BanIII

(manufactur d by Toyobo Co., Ltd.) at 37 • C for one hour for digestion. Next, to the mixtur , 2 µl (1 unit) of alkaline phosphatase (manufactured by Toyobo Co., Ltd.) was added, and the r sultant mixture was allowed to heat at 60 • C for 30 minutes for dephosphorylation at 5'-terminal of the DNA. Aft r that, the DNA was collected by phenol-chloroform treatment and the following ethanol precipitation.

The lambda-phage DNA cleavage product and the pHSG397 cleavage product both of which were thus obtained were dissolved in each 10 µl of TE. Next, 3.5 µl of each solution were mixed and the DNA cleavage products therein were ligated by reacting the mixture at 10 • C for two hours utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd.). The obtained DNA was utilized to transform E.coli (strain HB101), and plasmid DNA was purified from the obtained transformants. This plasmid DNA is pHSGcI_{857} formed by inserting Bg1II-BanIII fragment of ca.1100 base pairs including cI_{857} into pHSG397.

A Step of Inserting cI_{857} into pSH4

Two micrograms of pHSGcI_{857} was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme XhoI (manufactured by Nippon Gene Co., Ltd.) and BanIII (manufactured by Toyobo Co., Ltd.) at 37 • C for one hour for digestion. The cleaved DNA fragments were collected by phenol-chloroform treatment and the following ethanol precipitation. The collected DNA was incubated in 25 µl of Klenow solution containing two units of Krenow fragment at 22 • C for 30 minutes to convert a cohesive end of the DNA to a flush end. Next, the resultant solution was heated at 70 • C for five minutes and subjected to phenol-chloroform treatment and the following ethanol precipitation to collect the DNA.

On the other hand, 1 µg of pSH4 was incubated in 50 µl of High Buffer containing 10 units of restriction enzyme BamHI (manufactured by Nippon Gene Co., Ltd.) at 37 • C for one hour for digestion. The cleaved DNA was collected by phenol-chloroform treatment and the following ethanol precipitation. The collected DNA was incubated in 25 µl of Klenow solution containing 2 units of Klenow fragment at 22 • C for 30 minutes to convert a cohesive end of the DNA to a flush end. Next, the resultant solution was heated at 70 • C for five minutes, and subjected to phenol-chloroform treatment and the following ethanol precipitation to collect the resultant DNA.

The DNA fragments including cI_{857} and the cleaved pSH4 fragments both of which were thus obtained were dissolved in 10 µl of TE, respectively. Next, 3.5 µl of each solution was mixed and the DNA fragments were ligated by reacting the solution at 10 • C for two hours utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd.). The obtained DNA was utilized to transform E.coli (strain HB101), and plasmid DNA was purified from the obtained transformants. The obtained plasmid is pSH5 formed by inserting cI_{857} into plasmid pSH4.

A Step of Inserting a Complete Synthetic MAP Gene into pSH5

Two micrograms of pSH5 was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme XbaI (manufactured by Nippon Gene Co., Ltd.) and BanIII (manufactured by Toyobo Co., Ltd.) at 37 • C for one hour for digestion. The resultant solution was subjected to phenol-chloroform treatment and the following ethanol precipitation to collect the cleaved DNA.

Meanwhile, 2 µg of pMHI was digested and the cleaved DNA was collected by the same manner as said for pSH5. The pMHI here is a synthetic plasmid formed by inserting a complete synthetic MAP gene into the plasmid pUC19.

The DNA fragments derived from pSH5 and the fragments from pMHI thus obtained were dissolved into 10 µl of each TE, respectively. Next, 3.5 µl of each solution was mixed and the DNA fragments therein were ligated by reacting the resultant mixture at 10 • C for one hour utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd.). The combined DNA was used to transform E.coli (strain N99cI+), and plasmid DNA was purified from the obtained transformants. This plasmid is pSH6 formed by inserting a fragment of the complete synthetic MAP gene, which obtained by reacting with XbaI and BanIII, into the plasmid pSH5.

A Step of Inserting Signal Sequence Gene of OmpA into pSH6

Each single-stranded DNA of complementary DNA fragments having a base sequences shown in Fig. 1 was synthesized according to phosphoroamidide method utilizing a DNA synthesiz r (manufactured by Applied Biosystems Japan, 381A type). One microgram of each synthesized single-stranded DNA was incubated in 50 µl of said kinase solution containing 10 units of T4 kinase (manufactured by Toyobo Co., Ltd.) at 37 • C for one hour to phosphorylate 5'-terminal of the DNA. Each solution containing the

phosphorylated single-stranded DNA were mixed and the resultant solution was heated at 60°C for 20 minutes and allowed to stand at room temperature for 20 minutes for annealing to obtain double-stranded DNA. The obtained double-stranded DNA was collected by ethanol precipitation and dissolved in 10 µl of TE.

On the other hand, 1 µg of the plasmid pSH6 was incubated in 50 µl of High Buffer containing 10 units of each restriction enzyme NdeI and XbaI (both manufactured by Nippon Gene Co., Ltd.) at 37°C for one hour for digestion. The cleaved DNA was collected by subjecting the reacted solution to phenol-chloroform treatment and the following ethanol precipitation. The collected DNA was further dissolved in 10 µl of TE.

Three point five micro liter of the TE solution containing the annealed synthetic DNA and also 3.5 µl of the TE solution containing the cleaved pSH6 was mixed. The mixture was reacted at 10°C for two hours by utilizing the ligation kit (manufactured by Takara Syuzo Co., Ltd.) to combine the synthetic DNA and the cleaved DNA. The combined DNA was used to transform E.coli (strain N99cI+), and plasmid DNA was purified from the obtained transformants. This plasmid is plasmid pSH7 formed by inserting the gene of OmpA signal sequence into pSH6.

Expression of MAP Utilizing E.coli transformed with The Plasmid pSH6

E.coli (strain MM294) was transformed by the plasmid pSH6. The obtained transformants were cultured in 5 ml of LB medium (a mixture of 1% bact.trypton, 0.5% bact.yeast extract, 1% sodium chloride, and 0.1% glucose) containing 50 µg/ml of ampicillin at 30°C under the aerobic condition overnight. Next, the medium was added into M9CA medium (a mixture of 6g/l of disodium phosphate, 3g/l of potassium phosphate, 0.5g/l of sodium chloride, 1g/l of ammonium chloride, 2mM of magnesium sulphate, 0.1mM of calcium chloride, and 2g/l of glucose) containing 50 µg/ml of ampicillin and 4 µg/ml of thiamine hydrochloride to achieve a final concentration of 1%. The resultant solution was cultured at 30°C under the aerobic condition. Growth rate of the transformants was almost the same as that of E.coli transformants (strain MM294) which was transformed with plasmid pSH5 containing no MAP gene. It is apparent from this fact that the plasmid pSH6 did not affect the growth of E.coli.

When the absorbance of the medium at 550nm achieved 0.8, M9CA medium which had already been heated to 55°C was added to the medium in equivalent volume to accelerate the production of MAP. After that, the solution was further cultured at 42°C under the aerobic condition to have MAP accumulated in E.coli bodies.

After culture was terminated, the E.coli bodies were collected by centrifugation and suspended in 0.9% aqueous NaCl solution which is equivalent to the medium in volume. This suspension was further centrifuged to collect the E.coli bodies. The collected bodies were further suspended in 0.9% aqueous sodium chloride solution, followed by braking by means of a ultra sonic vibrator. The obtained sample was subjected to enzyme-linked immunosorbent assay (ELISA). The result was that 20 µg/l of MAP was produced.

Expression of MAP Utilizing E.coli Transformed with Plasmid pSH7

E.coli (strain MM294) was transformed by the plasmid pSH7. The obtained transformants were cultured with shaking in 5 ml of LB medium containing 50 µg/ml of amplicillin under the aerobic condition at 30°C overnight in the same manner as for pSH6. Next, the medium was added into M9CA medium containing 50 µg/ml of ampicillin and 4 µg/ml of thiamine hydrochloride to achieve a final concentration of 1%, followed by culture at 30°C under the aerobic condition in the same manner as for pSH6. The growth rate of the transformants was almost the same as that of E.coli transformants (strain MM294) which was transformed with the plasmid pSH5 containing no MAP gene. This fact reveals that the plasmid pSH7 did not affect the growth of the E.coli.

When absorbance of the medium at 550nm achieved 0.8, M9CA medium which had been already heated to 55°C was added to the medium in equivalent volume to accelerate MAP production. After that, the resultant medium was further cultured at 42°C under the aerobic condition to have MAP accumulated in the medium.

After the culture was terminated, the E.coli bodies were separated by centrifugation, and the residual solution was dialyzed with water. The dialyzed solution was subjected to an immunological analysis (ELISA) utilizing anti-MAP antibodies to detect extracellularly 200 μg/l of MAP in the solution. Additionally, western blotting analysis was performed to confirm presence of a protein having the same molecular weight as that of MAP in the solution.

Claims

1. A gene comprising the following base sequence:

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GCGCCTACTC TAGAAACCAT CGCTTCTCTG GACCTGAACA
CGCGGATGAG ATCTTTGGTA GCGAAGAGAC CTGGACTTGT

ACCCGACCAC CTACCTGTCT TTCATAACGA ATATCCGTAC
TGGGCTGGTG GATGGACAGA AAGTATTGCT TATAGGCATG

GAAAGTCGCA GACAAAACCG AACAGTGTAC CATCCAGAAA
CTTTCAGCGT CTGTTTTGGC TTGTCACATG GTAGGTCTTT

ATCTCTAAAA CCTTCACCCA GCGTTACTCT TACATAGACT
TAGAGATTTT GGAAGTGGGT CGCAATGAGA ATGTATCTGA

TGATCGTGAG CTCGACGCAG AAAATCACCC TAGCTATCGA
ACTAGCACTC GAGCTGCGTC TTTTAGTGGG ATCGATAGCT

CATGGCTGAC CTGTACGTTC TGGGTTACTC TGACATCGCT
GTACCGACTG GACATGCAAG ACCCAATGAG ACTGTAGCGA

AATAACAAGG GTCGTGCTTT CTTCTTCAAA GACGTGACTG
TTATTGTTCC CAGCACGAAA GAAGAAGTTT CTGCACTGAC

AGGCTGTTGC GAACAATTTC TTCCCGGGAG CTACAGGTAC
TCCGACAACG CTTGTTAAAG AAGGGCCCTC GATGTCCATG

TAATCGTATC AAATTAACCT TTACAGGTTC TTATGGCGAT
ATTAGCATAG TTTAATTGGA AATGTCCAAG AATACCGCTA

CTCGAGAAAA ACGGCGGACT ACGTAAGGAC AATCCCCTAG
GAGCTCTTTT TGCCGCCTGA TGCATTCCTG TTAGGGGATC

GTATCTTCCG TCTGGAAAAC TCGATAGTTA ACATTTATGG
CATAGAAGGC AGACCTTTTG AGCTATCAAT TGTAAATACC

CAAAGCTGGT GACGTTAAAA AACAGGCTAA ATTCTTCTTA
GTTTCGACCA CTGCAATTTT TTGTCCGATT TAAGAAGAAT

CTGGCTATCC AGATGGTTTC GGAGGCTGCG CGCTTTAAGT
GACCGATAGG TCTACCAAAG CCTCCGACGC GCGAAATTCA

ATATCAGTGA CAAAATCCCG TCTGAAAAAT ACGAAGAAGT
TATAGTCACT GTTTTAGGGC AGACTTTTTA TGCTTCTTCA

TACCGTTGAC GAATACATGA CCGCTCTGGA AAACAACTGG
ATGGCAACTG CTTATGTACT GGCGAGACCT TTTGTTGACC

GCTAAACTGT CTACGGCCGT ATACAACTCT AAGCCTTCTA
CGATTTGACA GATGCCGGCA TATGTTGAGA TTCGGAAGAT

CCACCACCGC TACCAAATGT CAGCTGGCTA CCTCTCCGGT
GGTGGTGGCG ATGGTTTACA GTCGACCGAT GGAGAGGCCA

TACCATCTCT CCGTGGATAT TCAAAACCGT CGAGGAAATC
ATGGTAGAGA GGCACCTATA AGTTTTGGCA GCTCCTTTAG

AAACTGGTTA TGGGTCTGCT TAAGTCTTCT TAATAA
TTTGACCAAT ACCCAGACGA ATTCAGAAGA ATTATT
```

said base sequence coding for MAP, wherein the gene includes in the upstream of the base sequence a gene which comprises the following base sequence:

TATGAAAAAGACAGCTATCGCGATTGCAGTGGCACTGGCT
ACTTTTTCTGTCGATAGCGCTAACGTCACCGTGACCGA

GGTTTCGCTACCGTAGCGCAGGCC GCGCCTACT
CCAAAGCGATGGCATCGCGTCCGG CGCGGATGAGATC

and which codes for OmpA signal sequence.

2. Recombinant plasmid having E.coli expression systems and the gene described in the claim 1 inserted.

3. Recombinant plasmid including P_L promotor derived from E.coli lambda-phage, cI_{857} repressor gene, and also the gene described in the claim 1 such that the gene can express in the E.coli.

4. E.coli transformant comprising the plasmid described in the claim 2 or 3.

5. A method for producing MAP comprising:
a step of culturing the E.coli transformants described in the claim 4 to express the gene described in the claim 1 which is introduced in said transformants and to induce them to produce MAP, and
a step of separating and purifying MAP which is extracellulary produced.

Patentansprüche

1. Gen, umfassend die folgende Basensequenz:

```
GCGCCTACTC TAGAAACCAT CGCTTCTCTG GACCTGAACA
CGCGGATGAG ATCTTTGGTA GCGAAGAGAC CTGGACTTGT

ACCCGACCAC CTACCTGTCT TTCATAACGA ATATCCGTAC
TGGGCTGGTG GATGGACAGA AAGTATTGCT TATAGGCATG

GAAAGTCGCA GACAAAACCG AACAGTGTAC CATCCAGAAA
CTTTCAGCGT CTGTTTTGGC TTGTCACATG GTAGGTCTTT

ATCTCTAAAA CCTTCACCCA GCGTTACTCT TACATAGACT
TAGAGATTTT GGAAGTGGGT CGCAATGAGA ATGTATCTGA

TGATCGTGAG CTCGACGCAG AAAATCACCC TAGCTATCGA
ACTAGCACTC GAGCTGCGTC TTTTAGTGGG ATCGATAGCT

CATGGCTGAC CTGTACGTTC TGGGTTACTC TGACATCGCT
GTACCGACTG GACATGCAAG ACCCAATGAG ACTGTAGCGA

AATAACAAGG GTCGTGCTTT CTTCTTCAAA GACGTGACTG
TTATTGTTCC CAGCACGAAA GAAGAAGTTT CTGCACTGAC

AGGCTGTTGC GAACAATTTC TTCCCGGGAG CTACAGGTAC
TCCGACAACG CTTGTTAAAG AAGGGCCCTC GATGTCCATG

TAATCGTATC AAATTAACCT TTACAGGTTC TTATGGCGAT
ATTAGCATAG TTTAATTGGA AATGTCCAAG AATACCGCTA

CTCGAGAAAA ACGGCGGACT ACGTAAGGAC AATCCCCTAG
GAGCTCTTTT TGCCGCCTGA TGCATTCCTG TTAGGGGATC

GTATCTTCCG TCTGGAAAAC TCGATAGTTA ACATTTATGG
CATAGAAGGC AGACCTTTTG AGCTATCAAT TGTAAATACC

CAAAGCTGGT GACGTTAAAA AACAGGCTAA ATTCTTCTTA
GTTTCGACCA CTGCAATTTT TTGTCCGATT TAAGAAGAAT

CTGGCTATCC AGATGGTTTC GGAGGCTGCG CGCTTTAAGT
GACCGATAGG TCTACCAAAG CCTCCGACGC GCGAAATTCA

ATATCAGTGA CAAAATCCCG TCTGAAAAAT ACGAAGAAGT
TATAGTCACT GTTTTAGGGC AGACTTTTTA TGCTTCTTCA

TACCGTTGAC GAATACATGA CCGCTCTGGA AAACAACTGG
ATGGCAACTG CTTATGTACT GGCGAGACCT TTTGTTGACC

GCTAAACTGT CTACGGCCGT ATACAACTCT AAGCCTTCTA
CGATTTGACA GATGCCGGCA TATGTTGAGA TTCGGAAGAT

CCACCACCGC TACCAAATGT CAGCTGGCTA CCTCTCCGGT
GGTGGTGGCG ATGGTTTACA GTCGACCGAT GGAGAGGCCA

TACCATCTCT CCGTGGATAT TCAAAACCGT CGAGGAAATC
ATGGTAGAGA GGCACCTATA AGTTTTGGCA GCTCCTTTAG

AAACTGGTTA TGGGTCTGCT TAAGTCTTCT TAATAA
TTTGACCAAT ACCCAGACGA ATTCAGAAGA ATTATT
```

wobei die Basensequenz für MAP codiert, wobei das Gen stromaufwärts von der Basensequenz ein Gen enthält, welches die folgende Basensequenz umfaßt:

```
TATGAAAAAGACAGCTATCGCGATTGCAGTGGCACTGGCT
ACTTTTTCTGTCGATAGCGCTAACGTCACCGTGACCGA

GGTTTCGCTACCGTAGCGCAGGCC GCGCCTACT
CCAAAGCGATGGCATCGCGTCCGG CGCGGATGAGATC
```

und welche für eine OmpA-Signalsequenz codiert.

2. Rekombinantes Plasmid mit E. coli-Expressionssystemen und dem in Anspruch 1 beschriebenen eingefügten Gen.

3. Rekombinantes Plasmid, das einen von der E. coli-Lambda-Phage abgeleiteten P_L-Promotor, das cI_{857}-Repressorgen und auch das in Anspruch 1 beschriebene Gen enthält, so daß das Gen in E. coli exprimiert werden kann.

4. E. coli-Transformante, umfassend das in Anspruch 2 oder 3 beschriebene Plasmid.

5. Verfahren zur Herstellung von MAP, umfassend:
einen Schritt zur Kultivierung von den in Anspruch 4 beschriebenen E. coli-Transformanten zur Expression des in Anspruch 1 beschriebenen Gens, welches in den Transformanten eingeführt wird, und um diese zur Herstellung von MAP zu veranlassen, und
einen Schritt zur Abtrennung und Reinigung von MAP, welches extrazellulär gebildet wird.

Rev ndications

1. Gène comprenant la séquence de bases suivante :

```
GCGCCTACTC TAGAAACCAT CGCTTCTCTG GACCTGAACA
CGCGGATGAG ATCTTTGGTA GCGAAGAGAC CTGGACTTGT

ACCCGACCAC CTACCTGTCT TTCATAACGA ATATCCGTAC
TGGGCTGGTG GATGGACAGA AAGTATTGCT TATAGGCATG

GAAAGTCGCA GACAAAACCG AACAGTGTAC CATCCAGAAA
CTTTCAGCGT CTGTTTTGGC TTGTCACATG GTAGGTCTTT

ATCTCTAAAA CCTTCACCCA GCGTTACTCT TACATAGACT
TAGAGATTTT GGAAGTGGGT CGCAATGAGA ATGTATCTGA

TGATCGTGAG CTCGACGCAG AAAATCACCC TAGCTATCGA
ACTAGCACTC GAGCTGCGTC TTTTAGTGGG ATCGATAGCT

CATGGCTGAC CTGTACGTTC TGGGTTACTC TGACATCGCT
GTACCGACTG GACATGCAAG ACCCAATGAG ACTGTAGCGA

AATAACAAGG GTCGTGCTTT CTTCTTCAAA GACGTGACTG
TTATTGTTCC CAGCACGAAA GAAGAAGTTT CTGCACTGAC

AGGCTGTTGC GAACAATTTC TTCCCGGGAG CTACAGGTAC
TCCGACAACG CTTGTTAAAG AAGGGCCCTC GATGTCCATG

TAATCGTATC AAATTAACCT TTACAGGTTC TTATGGCGAT
ATTAGCATAG TTTAATTGGA AATGTCCAAG AATACCGCTA

CTCGAGAAAA ACGGCGGACT ACGTAAGGAC AATCCCCTAG
GAGCTCTTTT TGCCGCCTGA TGCATTCCTG TTAGGGGATC

GTATCTTCCG TCTGGAAAAC TCGATAGTTA ACATTTATGG
CATAGAAGGC AGACCTTTTG AGCTATCAAT TGTAAATACC

CAAAGCTGGT GACGTTAAAA AACAGGCTAA ATTCTTCTTA
GTTTCGACCA CTGCAATTTT TTGTCCGATT TAAGAAGAAT

CTGGCTATCC AGATGGTTTC GGAGGCTGCG CGCTTTAAGT
GACCGATAGG TCTACCAAAG CCTCCGACGC GCGAAATTCA

ATATCAGTGA CAAAATCCCG TCTGAAAAAT ACGAAGAAGT
TATAGTCACT GTTTTAGGGC AGACTTTTTA TGCTTCTTCA

TACCGTTGAC GAATACATGA CCGCTCTGGA AAACAACTGG
ATGGCAACTG CTTATGTACT GGCGAGACCT TTTGTTGACC

GCTAAACTGT CTACGGCCGT ATACAACTCT AAGCCTTCTA
CGATTTGACA GATGCCGGCA TATGTTGAGA TTCGGAAGAT

CCACCACCGC TACCAAATGT CAGCTGGCTA CCTCTCCGGT
GGTGGTGGCG ATGGTTTACA GTCGACCGAT GGAGAGGCCA

TACCATCTCT CCGTGGATAT TCAAAACCGT CGAGGAAATC
ATGGTAGAGA GGCACCTATA AGTTTTGGCA GCTCCTTTAG

AAACTGGTTA TGGGTCTGCT TAAGTCTTCT TAATAA
TTTGACCAAT ACCCAGACGA ATTCAGAAGA ATTATT
```

ladite séquence de bases codant pour la protéine anti-virale de Mirabilis (PAM), le gène renfermant en amont de la séquence de bases un gène qui comprend la séquence de bases suivante :

```
TATGAAAAAGACAGCTATCGCGATTGCAGTGGCACTGGCT
  ACTTTTTCTGTCGATAGCGCTAACGTCACCGTGACCGA

GGTTTCGCTACCGTAGCGCAGGCC GCGCCTACT
CCAAAGCGATGGCATCGCGTCCGG CGCGGATGAGATC
```

et qui code pour la séqu nce signal de OmpA.

2. Plasmide recombiné dans lequel sont insérés des systèmes d'expression de E. coli et le gène décrit dans la revendication 1.

3. Plasmide recombiné renfermant un promoteur P_L provenant du phage lambda de E. coli, un gène de répresseur cI_{857}, et également le gène décrit dans la revendication 1, de façon que le gène puisse s'exprimer dans E. coli.

4. Transformant de E. coli, comprenant le plasmide décrit dans la revendication 2 ou 3.

5. Procédé de production de PAM, comprenant les étapes consistant à :
cultiver les transformants de E. coli décrits dans la revendication 4, pour exprimer le gène décrit dans la revendication 1, qui est introduit dans lesdits transformants, et amener ces derniers à produire de la PAM, et
séparer et purifier la PAM qui est produite de manière extracellulaire.

Fig. 1

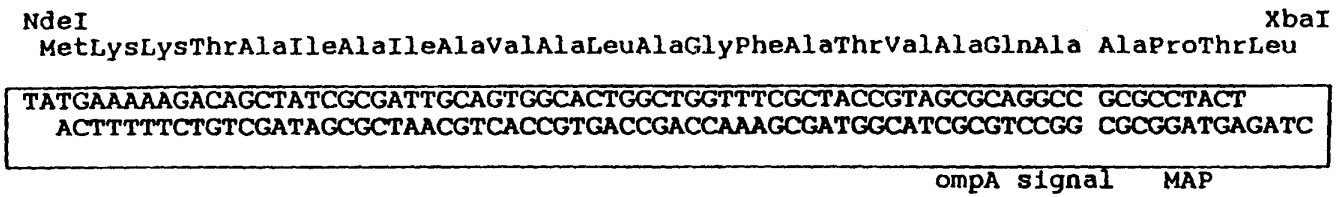
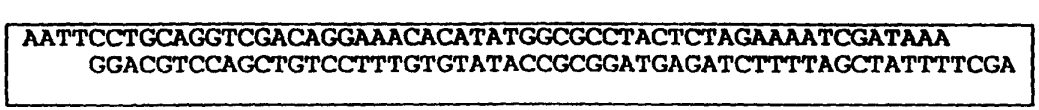


Fig. 3



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```
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CGCGGATGAG ATCTTTGGTA GCGAAGAGAC CTGGACTTGT TGGGCTGGTG GATGGACAGA

TTCATAACGA ATATCCGTAC GAAAGTCGCA GACAAAACCG AACAGTGTAC CATCCAGAAA
AAGTATTGCT TATAGGCATG CTTTCAGCGT CTGTTTTGGC TTGTCACATG GTAGGTCTTT

ATCTCTAAAA CCTTCACCCA GCGTTACTCT TACATAGACT TGATCGTGAG CTCGACGCAG
TAGAGATTTT GGAAGTGGGT CGCAATGAGA ATGTATCTGA ACTAGCACTC GACCTGCGTC

AAAATCACCC TAGCTATCGA CATGGCTGAC CTGTACGTTC TGGGTTACTC TGACATCGCT
TTTTAGTGGG ATCGATAGCT GTACCGACTG GACATGCAAG ACCCAATGAG ACTGTAGCGA

AATAACAAGG GTCGTGCTTT CTTCTTCAAA GACGTGACTG AGGCTGTTGC GAACAATTTC
TTATTGTTCC CAGCACGAAA GAAGAAGTTT CTGCACTGAC TCCGACAACG CTTGTTAAAG

TTCCCGGGAG CTACAGGTAC TAATCGTATC AAATTAACCT TTACAGGTTC TTATGGCGAT
AAGGGCCCTC GATGTCCATG ATTAGCATAG TTTAATTGGA AATGTCCAAG AATACCGCTA

CTCGAGAAAA ACGGCGGACT ACGTAAGGAC AATCCCCTAG GTATCTTCCG TCTGGAAAAC
GAGCTCTTTT TGCCGCCTGA TGCATTCCTG TTAGGGGATC CATAGAAGGC AGACCTTTTG

TCGATAGTTA ACATTTATGG CAAAGCTGGT GACGTTAAAA AACAGGCTAA ATTCTTCTTA
AGCTATCAAT TGTAAATACC GTTTCGACCA CTGCAATTTT TTGTCCGATT TAAGAAGAAT

CTGGCTATCC AGATGGTTTC GGAGGCTGCG CGCTTTAAGT ATATCAGTGA CAAAATCCCG
GACCGATAGG TCTACCAAAG CCTCCGACGC GCGAAATTCA TATAGTCACT GTTTTAGGGC

TCTGAAAAAT ACGAAGAAGT TACCGTTGAC GAATACATGA CCGCTCTGGA AAACAACTGG
AGACTTTTTA TGCTTCTTCA ATGGCAACTG CTTATGTACT GGCGAGACCT TTTGTTGACC

GCTAAACTGT CTACGGCCGT ATACAACTCT AAGCCTTCTA CCACCACCGC TACCAAATGT
CGATTTGACA GATGCCGCCA TATGTTGAGA TTCGGAAGAT GGTGGTGGCG ATGGTTTACA

CAGCTGGCTA CCTCTCCCGT TACCATCTCT CCGTGGATAT TCAAAACCGT CGAGGAAATC
GTCGACCGAT GGAGAGGCCA ATGGTAGAGA GGCACCTATA AGTTTTGGCA GCTCCTTTAG

AAACTGGTTA TGGGTCTGCT TAAGTCTTCT TAATAA
TTTGACCAAT ACCCAGACGA ATTCAGAAGA ATTATT
```

Fig. 2

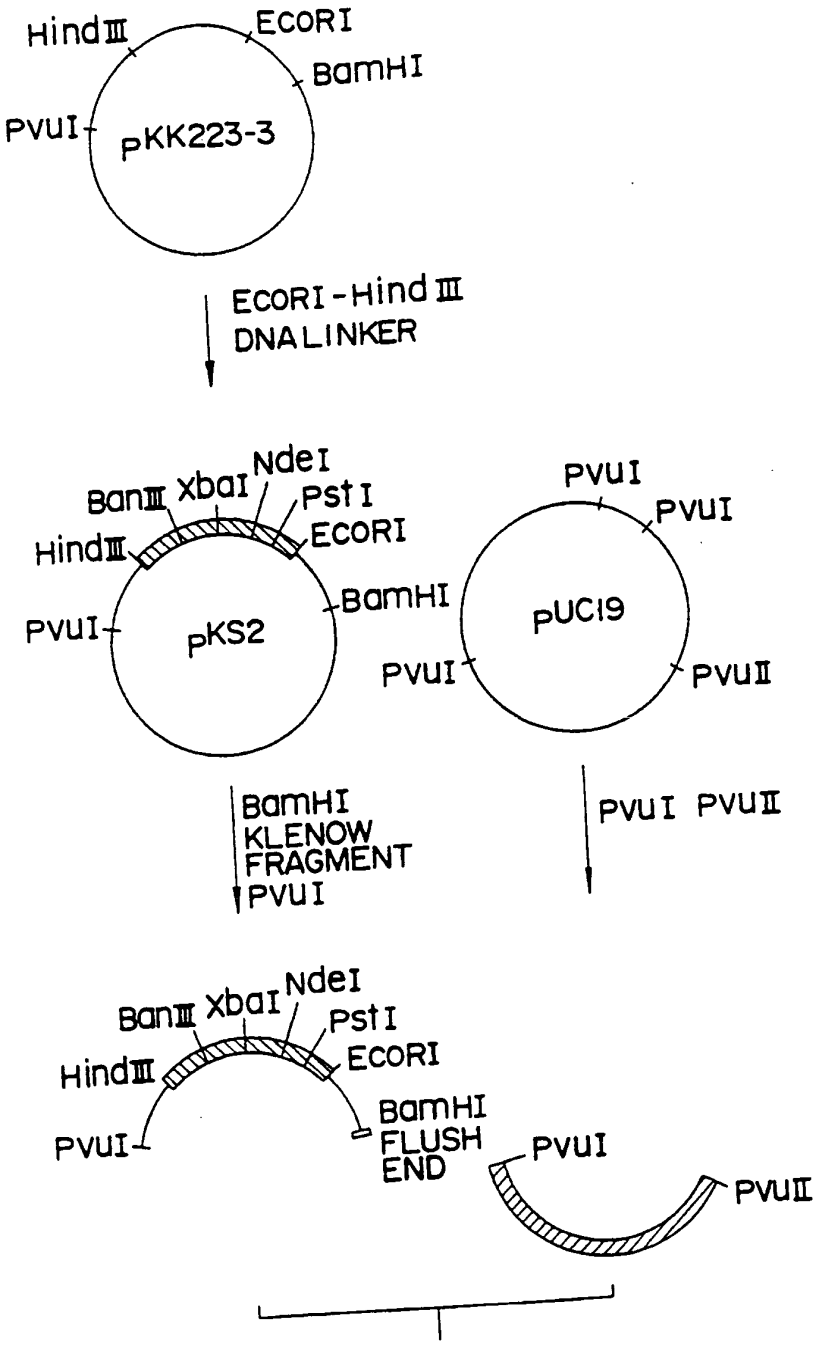
HindIII
EcoRI
BamHI
PvuI
pKK223-3
EcoRI-HindIII
DNA LINKER
BanIII
XbaI
NdeI
PstI
EcoRI
HindIII
BamHI
PvuI
pKS2
PvuI
PvuI
pUC19
PvuI
PvuII
BamHI
KLENOW
FRAGMENT
PvuI
PvuI PvuII
BanIII
XbaI
NdeI
PstI
EcoRI
HindIII
BamHI
FLUSH
END
PvuI
PvuI
PvuII

FIG. 4A

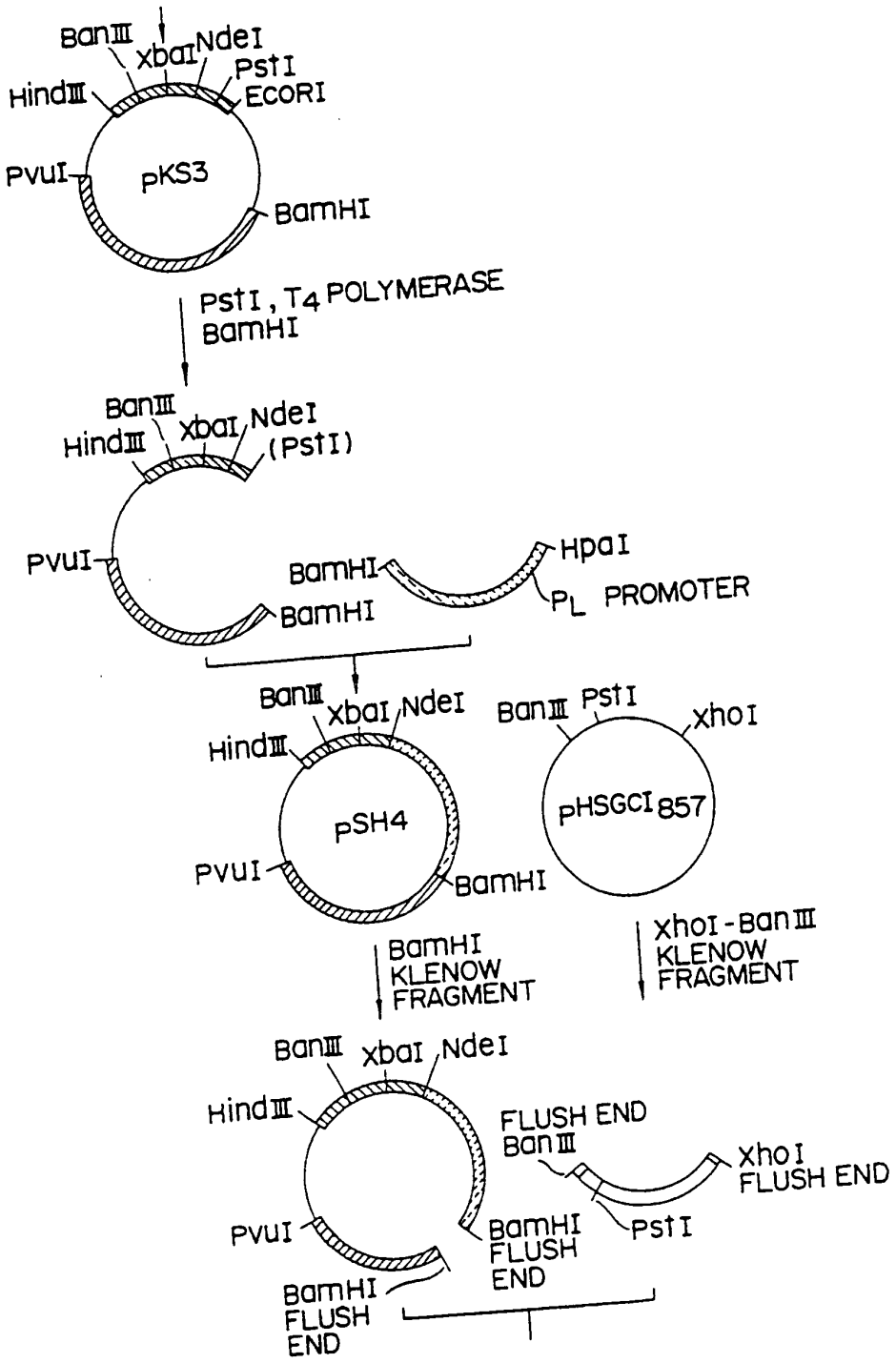
BanIII
XbaI
NdeI
PstI
HindIII
EcoRI
PvuI
pKS3
BamHI
PstI, T4 POLYMERASE
BamHI
BanIII
HindIII
XbaI
NdeI
(PstI)
PvuI
BamHI
HpaI
BamHI
PL PROMOTER
BanIII
XbaI
NdeI
HindIII
pSH4
PvuI
BamHI
BanIII
PstI
XhoI
pHSGCI 857
BamHI
KLENOW
FRAGMENT
XhoI-BanIII
KLENOW
FRAGMENT
BanIII
XbaI
NdeI
HindIII
FLUSH END
BanIII
XhoI
FLUSH END
PvuI
BamHI
FLUSH
END
PstI
BamHI
FLUSH
END

FIG. 4B

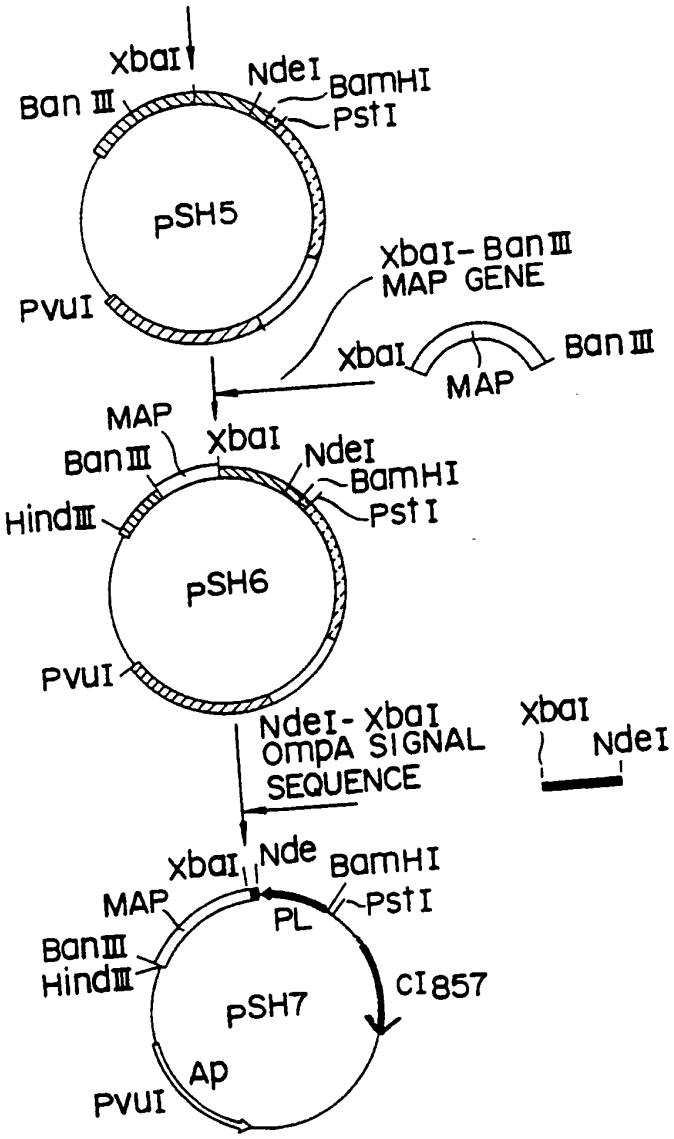
XbaI
NdeI
BamHI
PstI
Ban III
pSH5
PvuI
XbaI- Ban III
MAP GENE
XbaI
Ban III
MAP
MAP
XbaI
Ban III
NdeI
BamHI
PstI
HindIII
pSH6
PvuI
NdeI- XbaI
OmpA SIGNAL
SEQUENCE
XbaI
NdeI
XbaI
Nde
BamHI
MAP
PstI
PL
Ban III
HindIII
pSH7
CI857
Ap
PvuI

FIG. 4C